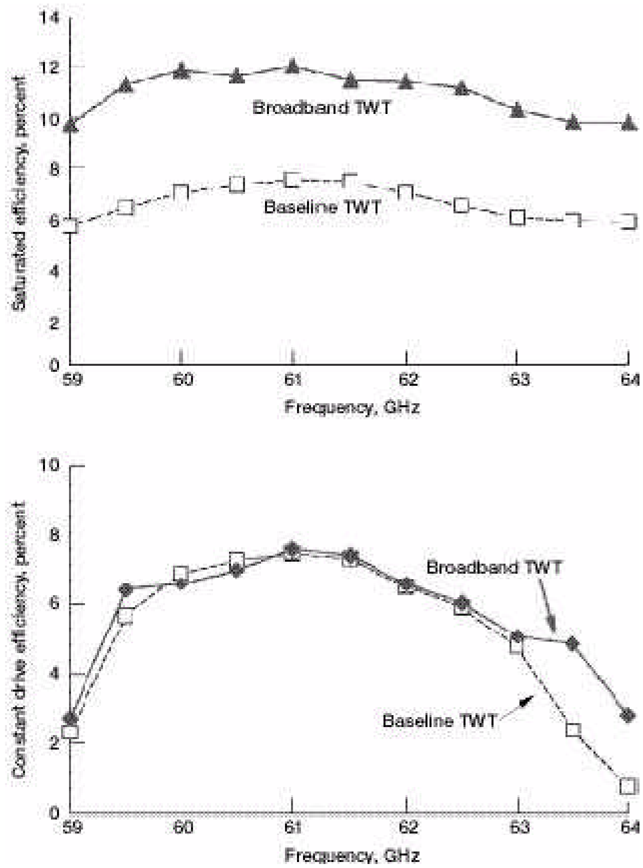
Power and Efficiency Optimized in Traveling-Wave Tubes Over a Broad Frequency Bandwidth



Top: Computed saturated power efficiency for a TWT designed with the first broadband design algorithm is considerably higher than that for the baseline Hughes 961HA TWT across the 59- to 64-gigahertz bandwidth. Bottom: Computed power efficiency with constant input drive power for a TWT designed with the second broadband design algorithm is comparable to that for the baseline Hughes 961HA TWT from 59 to 63 gigahertz but is considerably higher at 63.5 and 64 gigahertz.

A traveling-wave tube (TWT) is an electron beam device that is used to amplify electromagnetic communication waves at radio and microwave frequencies. TWT's are critical components in deep space probes, communication satellites, and high-power radar systems.

Power conversion efficiency is of paramount importance for TWT's employed in deep-space probes and communication satellites. A previous effort was very successful in increasing efficiency and power at a single frequency (ref. 1). Such an algorithm is sufficient for narrow bandwidth designs, but for optimal designs in applications that require high radiofrequency power over a wide bandwidth, such as high-density communications or high-resolution radar, the variation of the circuit response with respect to frequency must be considered. This work at the NASA Glenn Research Center is the first to develop techniques for optimizing TWT efficiency and output power over a broad frequency bandwidth (ref. 2).

The techniques are based on simulated annealing, which has the advantage over conventional optimization techniques in that it enables the best possible solution to be obtained (ref. 3). Two new broadband simulated annealing algorithms were developed that optimize (1) minimum saturated power efficiency over a frequency bandwidth and (2) simultaneous bandwidth and minimum power efficiency over the frequency band with constant input power. The algorithms were incorporated into the NASA coupled-cavity TWT computer model (ref. 4) and used to design optimal phase velocity tapers using the 59- to 64-GHz Hughes 961HA coupled-cavity TWT as a baseline model. In comparison to the baseline design, the computational results of the first broad-band design algorithm show an improvement of 73.9 percent in minimum saturated efficiency (see the top graph). The second broadband design algorithm (see the bottom graph) improves minimum radiofrequency efficiency with constant input power drive by a factor of 2.7 at the high band edge (64 GHz) and increases simultaneous bandwidth by 500 MHz.

References

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